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*Phagocata albata*, a New Probably Subterranean  
Freshwater Planarian, from Hokkaido<sup>1)</sup>

*With 5 Text-figures*

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(Communicated by T. UCHIDA)*

The material for this article was collected by the latter of the two authors in summer of 1956 from a small spring-fed pool near Toyotomi Hot Spring, North Hokkaido. From this locality, about 20 unpigmented small planarians were collected. On investigation, the living worms and several preserved specimens proved to be in a sexually immature state. In the laboratory cultures, however, we observed in several worms a development of sexual organs. We also succeeded in obtaining two ovoid cocoons of this species.

A cursory examination of these specimens showed that there is every reason for placing this animal in the genus *Phagocata*. As a result of a more detailed study, we have come to the conclusion that our present form is a hitherto undescribed new species.

The worms were killed by 2% HCl and were fixed in Bouin's fluid. The series were stained with Delafield's haematoxylin and eosin.

Order TRICLADIDA

Suborder PALUDICOLA or PROBURSALIA

Family PLANARIIDAE

Genus *PHAGOCATA* Leidy, 1847

*Phagocata albata*, new species

*Description.* This is a small and rather slender species with typical appearance of the genus *Phagocata*. The body form and the enlarged sketch of

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1) Contribution No. 515 from the Zoological Institute, Faculty of Science, Hokkaido University, Sapporo, Japan,

the head region of the species in life are shown in Figure 1 (A and B).

Mature worms in creeping state may reach a length of 12 mm and a width of 1.5 mm, but they are generally shorter, about 8–10 mm in length. The body is unpigmented and usually appears white or somewhat translucent when the intestine is empty. After feeding, the contents of the intestine are visible; the culture worms usually show a brownish, reddish or greyish intestine. All regions aside from the intestinal branches, are always white.

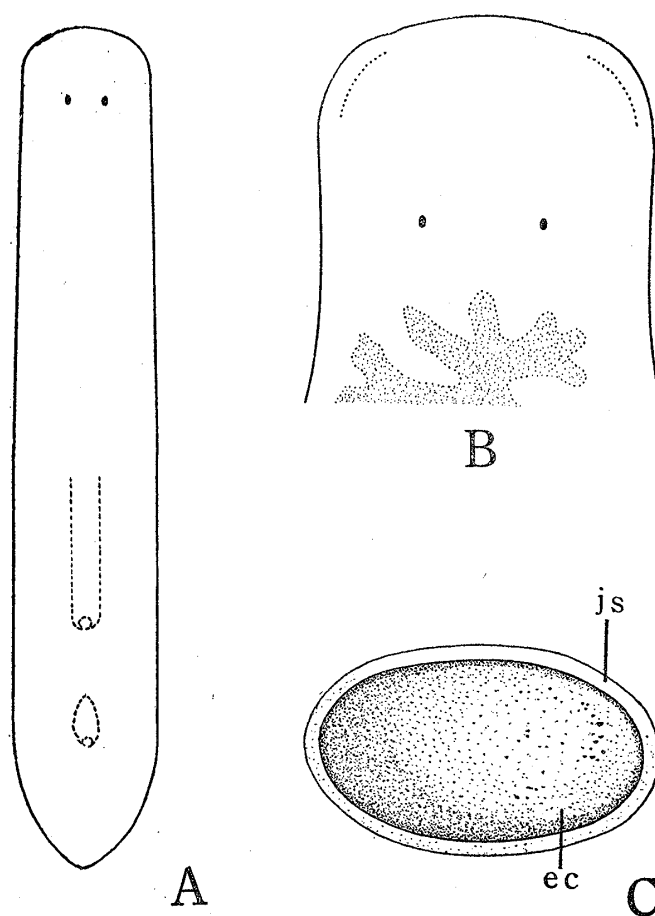


Fig. 1. *Phagocata albata*, new species. A: sketch of living specimen. Actual length, 12 mm. B: enlarged sketch of the head region. C: egg capsule (cocoon). Actual size, 1.0×1.8 mm. (ec) egg capsule, (js) jelly-like substance surrounding the egg capsule.

In the living worms the anterior end is truncated, with a slightly bulging frontal outline and rounded lateral corners (without definite tentacles). Behind the head, the body gradually becomes slightly broader, until it reaches its greatest width. From there the lateral margins of the body run approximately parallel to the levels of the mouth and the genital pore, and meet in a bluntly pointed posterior end,

Usually the worm has two rather small eyes. The distance between them is almost equal to that of one-fourth of the head width at the eye level and is far removed from the frontal end. No supernumerary (or accessory) eyes were observed in our material. Near the eyes there is a pair of auricular sense organs, but they cannot be recognized in the living worms. In the fully grown worms the pharynx is situated somewhat behind the middle of the body and measures about one-fifth to one-sixth of the body length. The copulatory organs occupy the anterior half of the postpharyngeal region.

In histological sections, the epidermis, the basement membrane, the subepidermal musculature and the rhabdite-forming cells did not present any special features. We found, however, that the epithelium was partly caved in in the center of the ventral anterior of the head (Fig. 2). The cells here lack cilia and rhabdites. Histologically, they are pierced by the gland ducts which provide a coarsely granular, feebly eosinophilic secretion. This organ has no muscular differentiation. Phylogenetically, it is probably related to the adhesive (or grasping) organ found in many planarian species of the family Dendrocoelidae. The marginal adhesive zone, characterized by its eosinophilous gland cells, is mainly seen below the anterior and posterior margins of the body. The worm moves by gliding only, without looping.

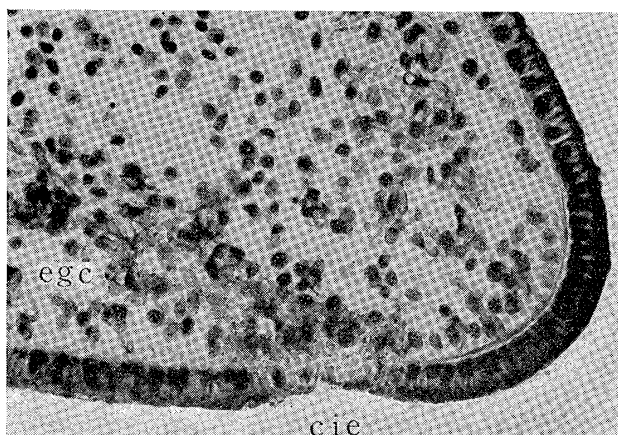


Fig. 2. Sagittal section of the caved-in epithelium in the center of the ventral anterior of the head (No. 187 b). (cie) caved-in epithelium, (egc) eosinophilic gland cells.

The pharynx shows the structure typical of the family Planariidae: the muscular fibres of the internal zone consist of two distinct layers, a thick inner circular layer and a narrow outer longitudinal one. Mature worms have from 10 to 15 branches on each side of the anterior intestinal trunk and from 15 to 20 branches on the lateral side of each posterior trunk; numerous short medial branches are seen in both the pharyngeal and postpharyngeal regions. The number of the intestinal branches, however, varies to some extent according to the size of the worm.

The testes are numerous and extend in the lateral regions from the level

shortly behind the ovaries almost to the posterior end of the body. Sagittal sections show that their position is predominantly ventral, below the intestinal branches. In the fully matured worm, a total number of 30 to 40 testes was observed on each side of the body. Inside of each testis, cells in various stages of spermatogenesis were found; in the central cavity of the testis, a tangled mass of spermatozoa was observed (Fig. 3A).

There is a pair of ovaries in the usual anterior portion, immediately below the second intestinal branch (Fig. 3B). Numerous mature ova were seen in the

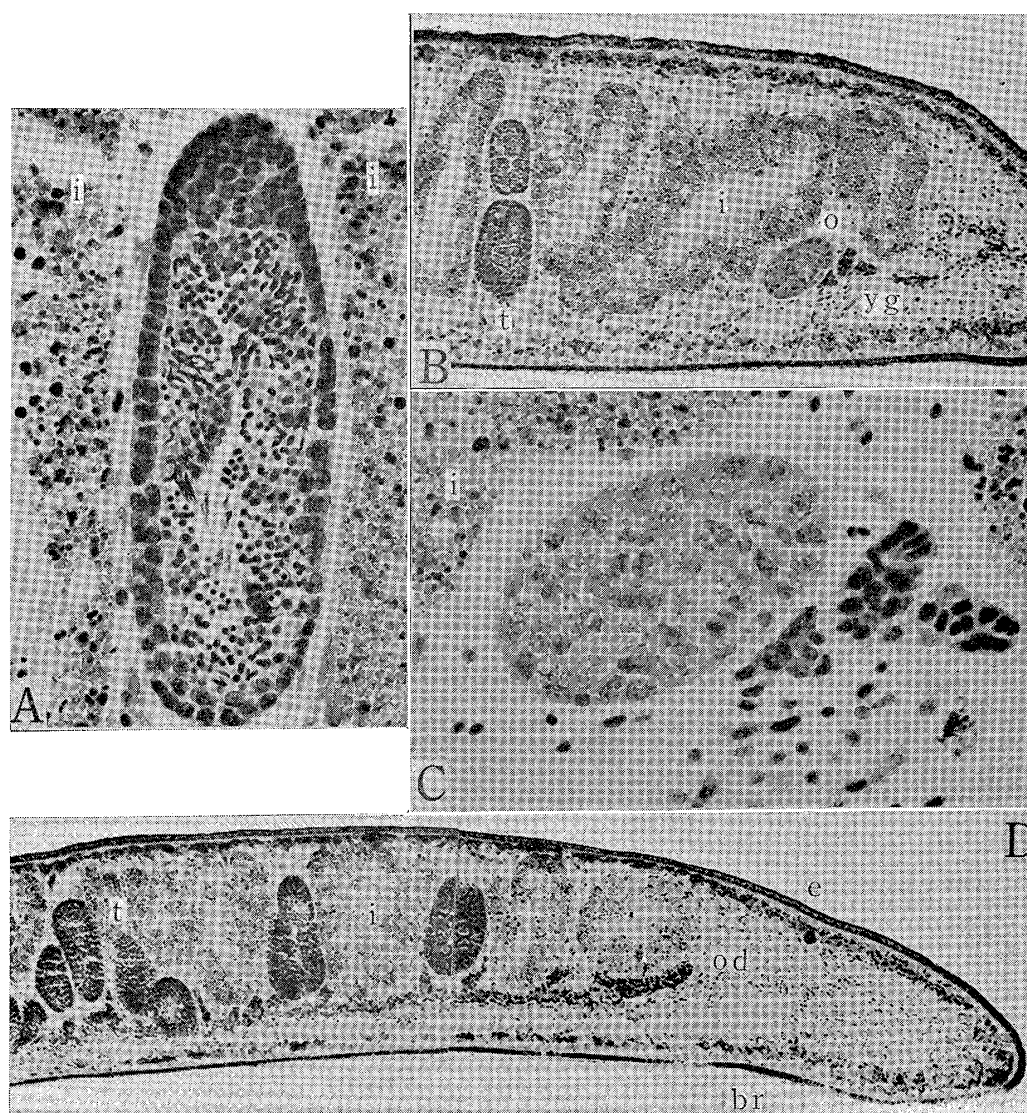


Fig. 3. Reproductive system. **A**: testis (No. 187 c). Notice the various stages of spermatogenesis and the mass of spermatozoa. **B**: sagittal section of the prepharyngeal region, showing the situations of ovary, yolk glands, testes, and intestine (No. 187 b). **C**: ovary and yolk glands (No. 187 b). Notice the mature ova. **D**: sagittal section of the prepharyngeal region, showing the situations of eye, brain, ovovitelline duct, yolk glands, testes, and intestine (No. 187 e). (br) brain, (e) eye, (i) intestine, (o) ovary, (od) ovovitelline duct, (t) testis, (yg) yolk gland.

ovary (Fig. 3C). The two ovovitelline ducts (or oviducts) spring from the dorso-lateral surface of the ovaries. They run backwards, near the dorsal side of each nerve cord, receiving the ducts of the yolk glands along their entire course (Fig. 3D). The yolk glands or vitellaria, which appear as many clusters of large and darkly stained cells, are generally distributed over the parenchyma, occupying chiefly the lateral and dorsal regions of the body.

The copulatory apparatus, re-constructed from several sets of sections, is shown in sagittal view in Figure 4; the microphotographs of the copulatory apparatus of three different worms are shown in Figure 5 (A, B and C).

The genital pore, situated as usually about midway between the mouth and the posterior end of the body, leads to a relatively small common genital antrum. It continues dorsally into the canal of the copulatory bursa or the vagina, anteriorly into the male antrum. The well-developed male antrum is almost entirely occupied by the penis. In some slides the general appearance of the genital antrum somewhat varies, depending on the states of muscular contraction at the time of fixation of the worms. In this species, however, we observed that, in general, the projecting diaphragm divides the genital antrum into the male and the common parts. The outer wall of the genital antrum is lined with a rather flat glandular epithelium. Under it there are two layers of muscle fibres, one circular and the other longitudinal.

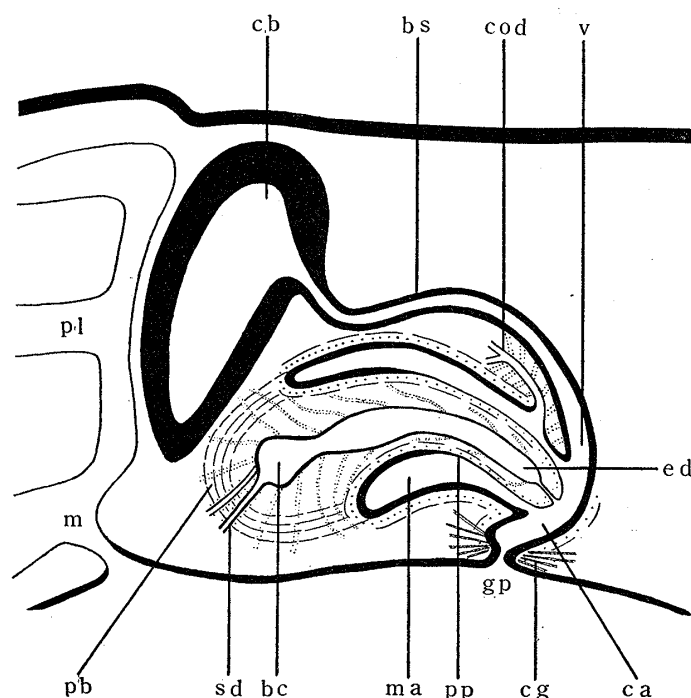


Fig. 4. Diagram showing the sagittal view of the copulatory apparatus. (bc) bulbar cavity, (bs) bursa stalk, (ca) common antrum, (cb) copulatory bursa, (cg) cement gland, (cod) common ovovitelline duct, (ed) ejaculatory duct, (gp) genital pore, (m) mouth, (ma) male antrum, (pb) penis bulb, (pl) pharynx lumen, (pp) penis papilla, (sd) sperm duct, (v) vagina.

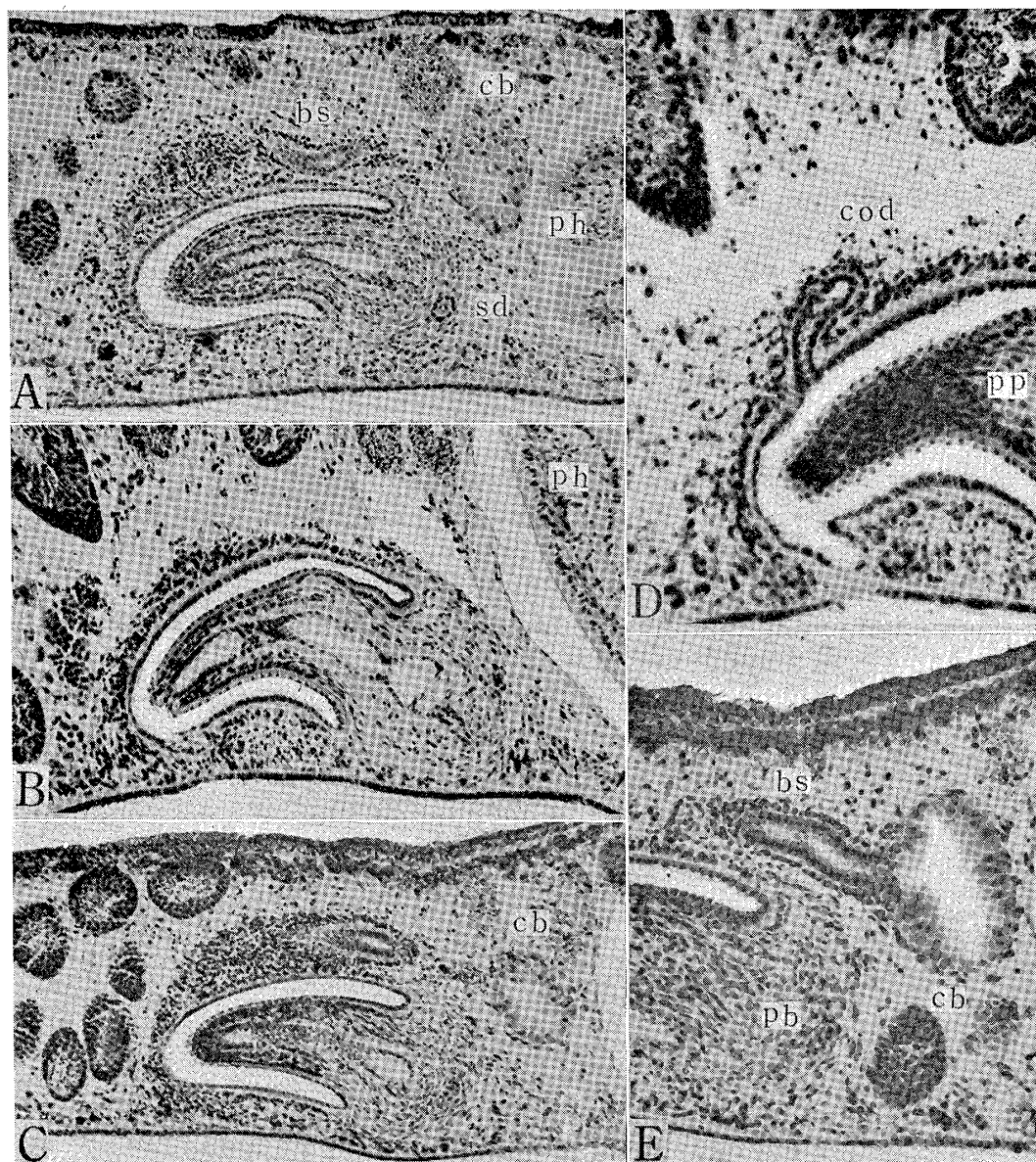


Fig. 5. Sagittal sections of the copulatory apparatus. **A:** penis (No. 187 b). **B:** penis (No. 187 c). **C:** penis (No. 187 e). Notice the shape of the penis lumen. **D:** common ovovitelline duct (No. 187 c). **E:** copulatory bursa (No. 187 e). (bs) bursa stalk, (cb) copulatory bursa, (cod) common ovovitelline duct, (ph) pharynx, (pp) penis papilla, (sd) sperm duct.

The two oviducts approach the midline in the region of the copulatory apparatus and join each other and form a rather short common ovovitelline duct (Fig. 5D). Just before joining the bursa stalk the male antrum receives the common ovovitelline duct into its dorsal wall of the posterior part. The greater part of the common ovovitelline duct is connected with numerous eosinophilic glands. The cell bodies of these glands are scattered in the surrounding parenchyma. Several outlets of the cement glands open on the wall between the genital pore



and the common antrum; the secretion of the glands is heavily stained with eosin.

The penis consists of a relatively well-developed bulb embedded in the parenchyma and a moderately long, bluntly pointed, finger-shaped papilla. It appears somewhat ventrally curved. The bulb is highly muscular in nature and distinctly marked off from the surrounding parenchyma. The papilla is rather muscular and is symmetrical in shape. The nature of the histological structure of the papilla is very similar to that of the male antrum; namely, the outer wall of the papilla is covered with a flat glandular epithelium and the muscles consist of circular and longitudinal layers.

The two sperm ducts (or vasa deferentia) run backwards along the lateral side of each ventral nerve cord. In our material, there is, in fact, no development of the spermiducal vesicles, a tubular or succiform expansion of the sperm ducts as found in many freshwater planarians. The sperm ducts, ascending from below into the penis bulb, enter the bulbar cavity separately. This is a rounded but small cavity and continues through the penis papilla as a differentiation between the bulbar cavity and the ejaculatory duct. The ejaculatory duct opens to the tip of the papilla. The penis lumen of both the bulb and the papilla receive many cyanophilic gland cells in its entire length.

The copulatory bursa, a rather small sac, is situated at a dorsal portion between the penis bulb and the pharyngeal chamber. This organ varies markedly in shape according to the state at the time of fixation; typically, it is of semi-spherical or oval shape as shown in Figure 5 (E). The lumen of the copulatory bursa is lined with a tall and very thick glandular epithelium. The bursa canal or bursa stalk is a long narrow duct passing posteriorly above the penis and curving ventrally till it reaches the genital antrum. The canal is internally lined with a cubical glandular epithelium and surrounded by muscle fibres. The terminal part of the canal (or vagina) is somewhat expanded, but does not show any histological peculiarities.

*Taxonomic Remarks and Differential Diagnosis.* Up to the present, several species of the genus *Phagocata* from the north-eastern part of the Far East and the North Pacific areas have been described. The distinct species are: *Phagocata vivida* (Ijima et Kaburaki, 1916), *Phagocata kawakatsui* Okugawa (1956) and *Phagocata? papillifera* (Ijima et Kaburaki, 1916) from Japan; *Phagocata uënoi* Okugawa (1939) and *Phagocata miyadaii* Okugawa (1939) from Manchuria; *Phagocata coarctata* (Arndt 1922) from Primorsk (the vicinity of Vladivostok); *Phagocata nivea* Kenk (1953) from Alaska. *Phagocata? papillifera*, probably a subterranean species, have not been studied from a modern taxonomic viewpoint, because the materials have not been obtained again in the type locality (Tokyo, Japan). The anatomy of the reproductive system of *Phagocata coarctata* is rather well known, although no fully mature specimens of this species have been studied.

From East Siberia and the Lake Baikal region, the two species, *Penecurva sibirica* (Zabusov, 1903a) and *Penecurva fontinalis* (Zabusov, 1903b), are known (cf. Basikalova, 1947; Livanow and Zabusova, 1940; Zabusova, 1960). The genus *Penecurva* was founded by Livanow and Zabusova (1940) on the Siberian species. These authors recognized the close relation of this new genus to the genus

*Fonticola* (i. e. *Phagocata*), but separated it from the latter on account of the following character: the penis lumen opens ventrally to the tip of the penis papilla. According to Kenk's opinion, however, this character apparently is inadequate as a basis for the establishment of a new genus (cf. Kenk, 1953, p. 168). These two species may belong to the genus *Phagocata*. From Kamchatka Peninsula and the Kuril Islands, no species of the genus *Phagocata* or the specimens of what seem to be members of this genus have been reported so far (cf. Miyadi, 1937; Zabusova, 1929, 1936, 1956).

Moreover, the north-eastern part of the Far East and the North Pacific areas have several unidentified species that may belong to this genus. *Planaria pellucida* Ijima et Kaburaki (1916) from South Sakhalin was described on a few immature specimens. Arndt's records (1918, 1921, 1922) of *Planaria alpina* from North Manchuria, Primorsk and Siberia are misidentifications (probably belongs to *Penecurva*; cf. Livanow and Zabusova, 1940, pp. 152-153). Basikalova's unpigmented *Penecurva* sp. (1947) from the Baikal region are immature specimens.

In neighbouring areas of Japan, the majority of the species of the genus *Phagocata* are pigmented forms. And only the four species, *Phagocata nivea*, *Phagocata coarctata*, *Phagocata? pellucida* and *Phagocata? sp.* of Lake Baikal, are unpigmented forms. Externally, the latter three white planarians differ from *Phagocata albata* in having a different contour of the head. On the other hand, *Phagocata albata* has a great resemblance to Alaskan *Phagocata nivea* not only in external appearance but also in the anatomical structure of the reproductive system. *Phagocata albata* differs from the very closely related Alaskan form in the following points: *Phagocata albata* has a copulatory bursa of medium size, a slender bursa stalk, a rather short common ovovitelline duct, and a moderately long, bluntly pointed, finger-shaped symmetrical penis papilla. There is a striking resemblance between the form of the body and cocoons of *Phagocata albata* and that of *Phagocata kawakatsui*. But they differ in the colour of the body and in the details of the copulatory apparatus. In short, on viewing the above diagnosis and the zoogeography of the probursalian fauna in the Far East, Alaska and the Japanese Islands, we believe that these three species are, undoubtedly, closely related.

*Holotype*. One set of sagittal serial sections (Specimen No. 187c, 2 slides) deposited in Professor Ichikawa's room of the Zoological Institute, Faculty of Science, Hokkaido University; also some other sections (No. 169, No. 187a, b, d and e).

*Locality*. A small spring-fed pool, near Toyotomi Hot Spring, in North Hokkaido (altitude, 60 m; Aug. 28, 1956; coll. M. Kawakatsu).

*Ecology*. The habitat of *Phagocata albata* is as follows: shallow, stagnant water; bottom sands, covered with many dead leaves (13.5°C, pH 5.2). In this habitat, the worms were hidden under the ground at a depth of about 10 cm. Therefore, it is highly probable that *Phagocata albata* is a subterranean inhabitant.

*Note on Culture*. In the refrigerator culture (5-10°C), the sexual organ was developed in a few well-fed worms from December, 1956 to March, 1957. It



was observed that no worms fissioned and only two cocoons were laid (March 18, 1957). The cocoon is elliptical or ovoid in shape and attained  $1.0 \times 1.7$ – $1.8$  mm. It is coated with translucent adhesive secretion of the cement glands and is reddish in colour at first but soon darkens. Unfortunately, no cocoons were hatched.

#### APPENDIX

From a water pump of the Wakkanai Forestry Office, Wakkanai City, in North Hokkaido, a fair number of a species of *Phagocata* were found (cf. Kawakatsu 1960, p. 620. altitude, 20 m; Aug. 29 and Sep. 3, 1957;  $14.0$ – $15.0^{\circ}\text{C}$ , pH 5.8–6.0; coll. M. Kawakatsu). However, no sexual specimens were procured. In the refrigerator culture, several of these worms seemed to form the genital organs and they laid one ovoid cocoon (March, 1958). Unfortunately these mature worms were lost by accident. We examined the several sets of serial sections of the surviving worms, but no fully mature worms were found (No. 213 a, b, c, d, e, f and g, No. 233).

*Description.* Externally indistinguishable from *Phagocata albata*; usually with two small eyes, sometimes eyeless; small, slender, 5–8 mm in length; white or translucent in life; testes extending to the posterior end; penis papilla pointed (not fully differentiated).

This white subterranean *Phagocata* could be *Phagocata albata*, but in the lack of sexually mature material a correct identification is impossible.

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